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(54) Connecting reinforcement rods

(57) Concrete reinforcing bars 12, 14 are joined end to end by inserting them into the open ends of a splicing sleeve which is then filled under pressure with a synthetic resin. The inner surface of the sleeve includes a plurality of grooves 18 which define conical surfaces arranged in a continuous series and which cooperate with the cured resin and irregular external surfaces of the bars to effect a very strong joint. The sleeve includes a number of longitudinally spaced injection apertures 28, which may be selectively plugged. Means also are provided to facilitate initial placement and orientation of the sleeve with respect to the bars to be joined. In a modification, one end of the sleeve is internally threaded to receive a threaded rod.

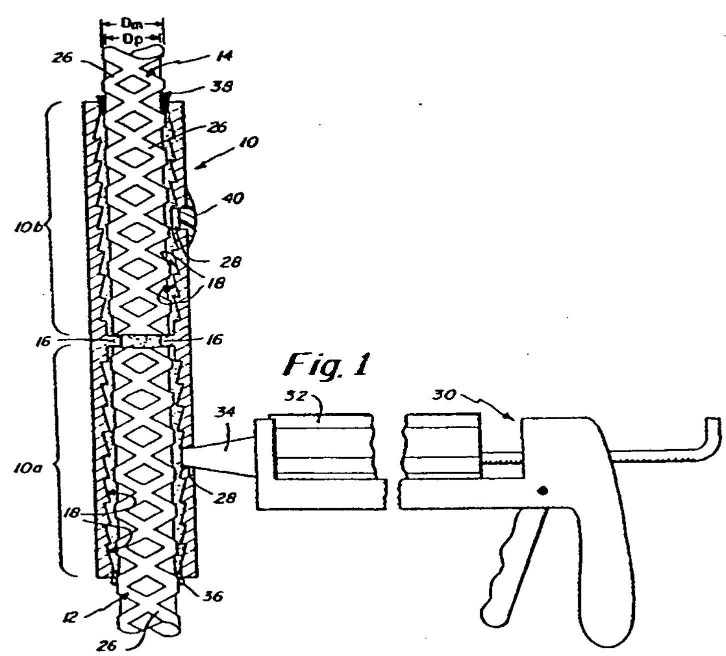

Fig. 1

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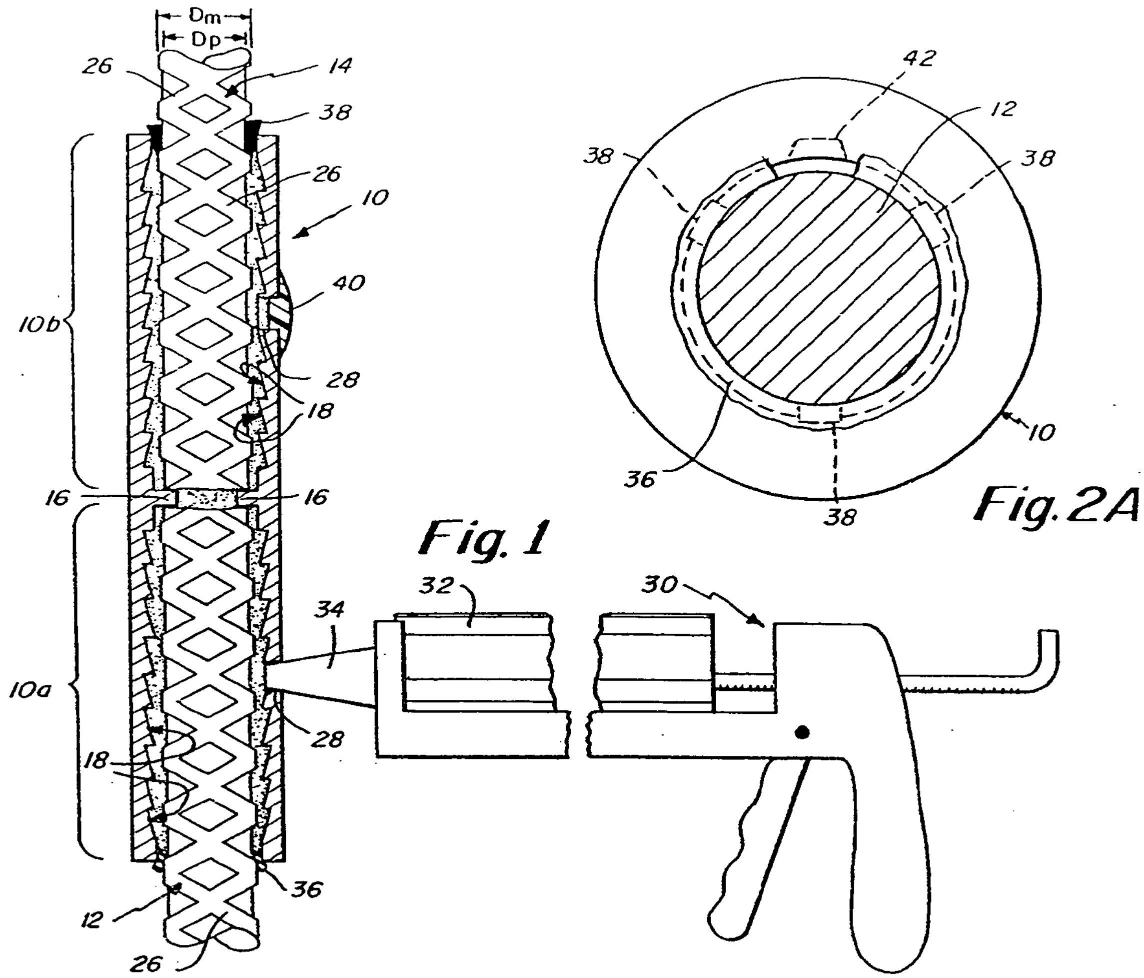


Fig. 1

Fig. 2A

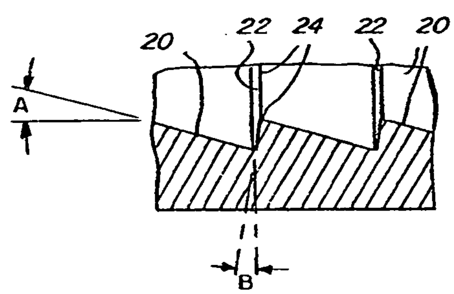


Fig. 8A

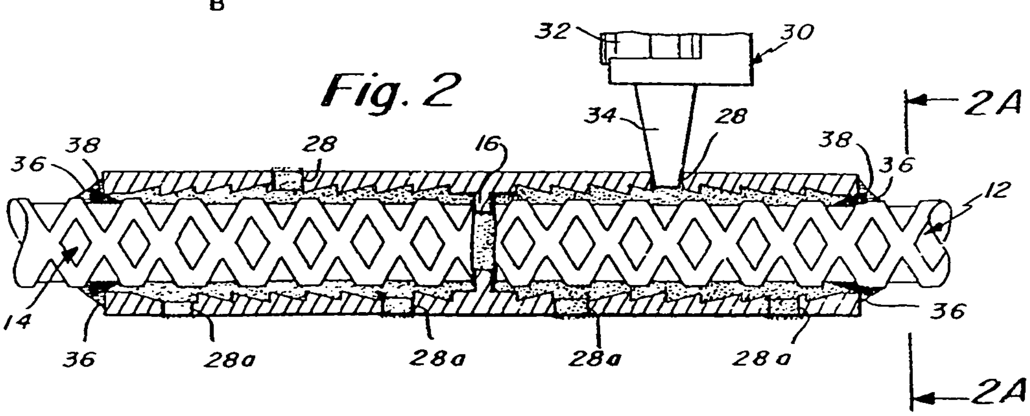


Fig. 2

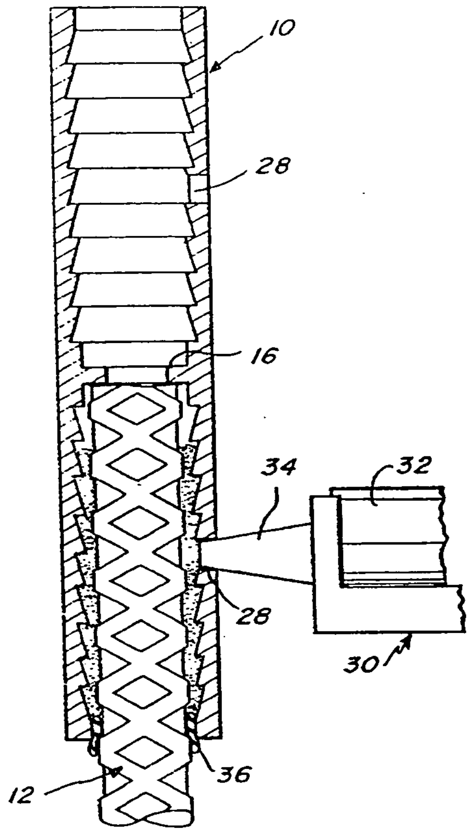


Fig.3

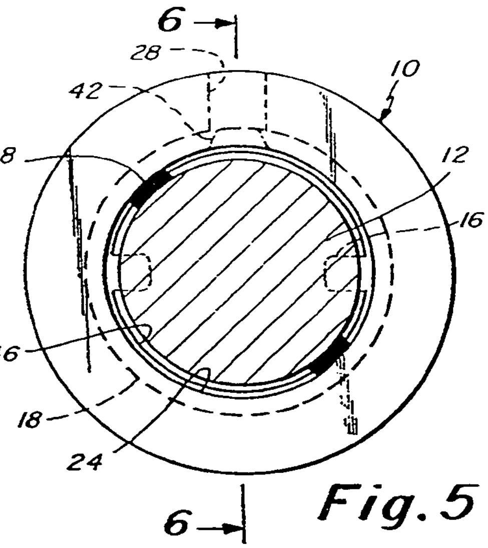


Fig.5

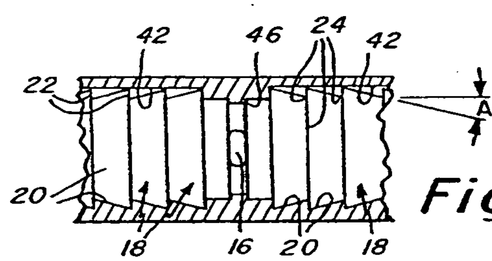


Fig.6

Fig. 4

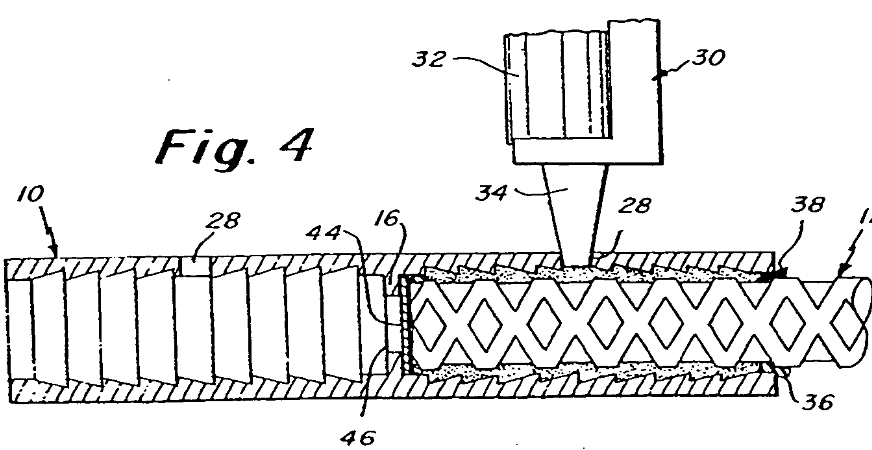


Fig.7

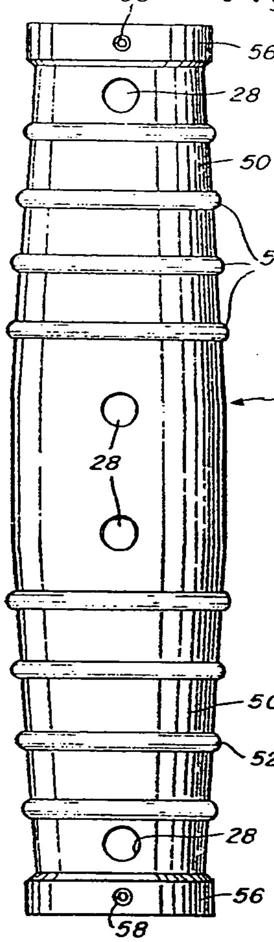


Fig. 8

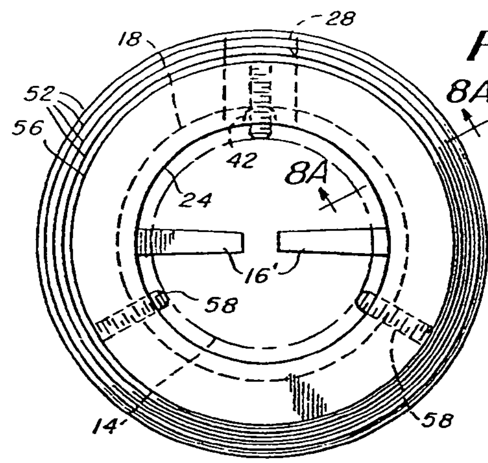


Fig. 9

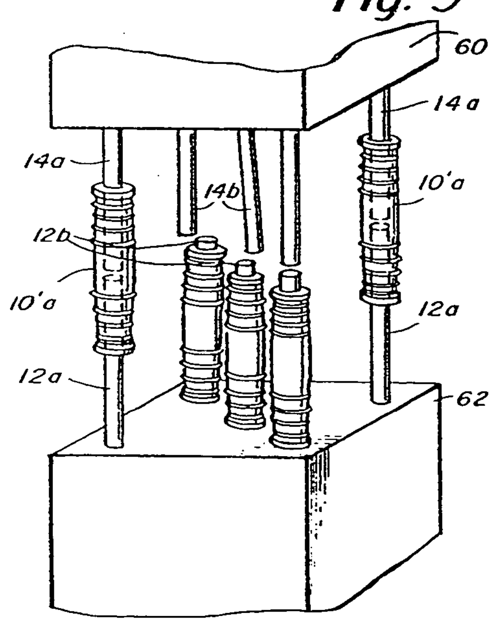


Fig.10

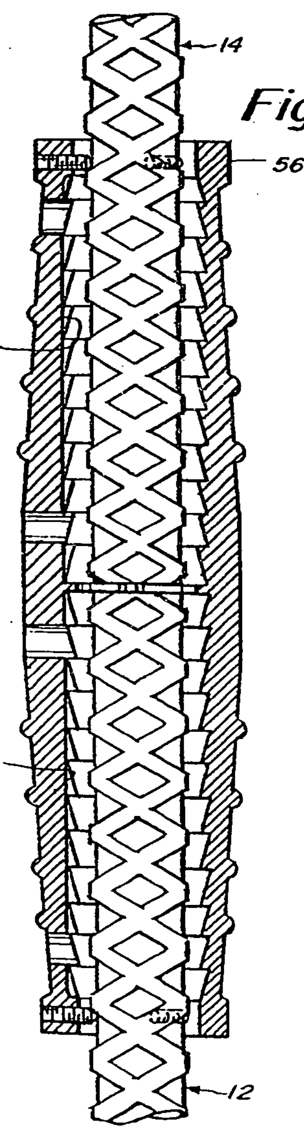
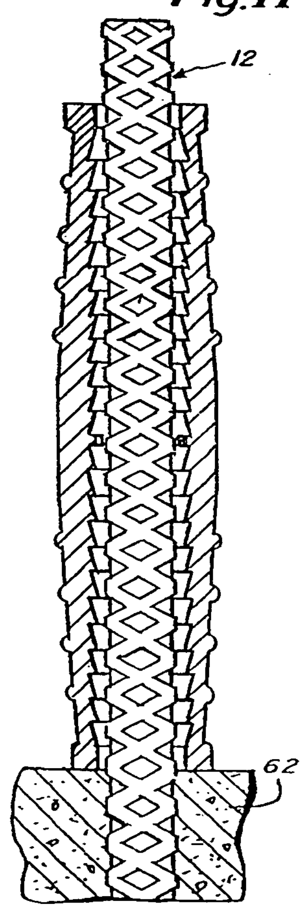


Fig.11



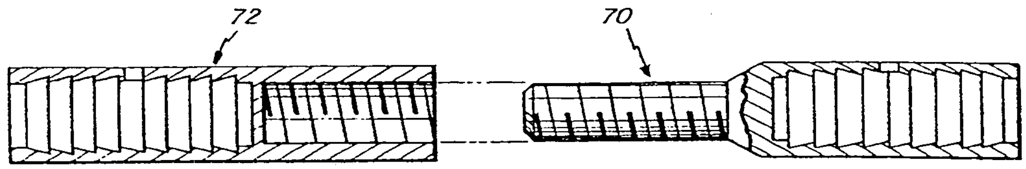


Fig. 12

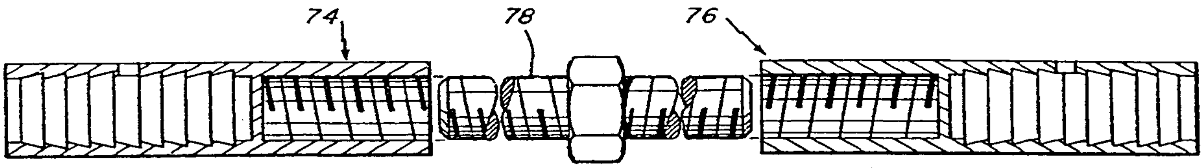


Fig. 13

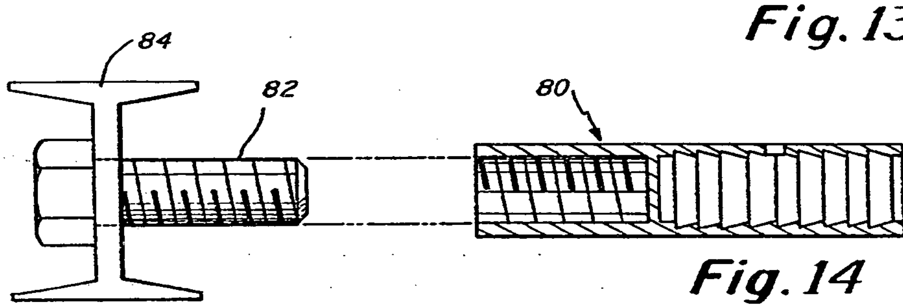


Fig. 14

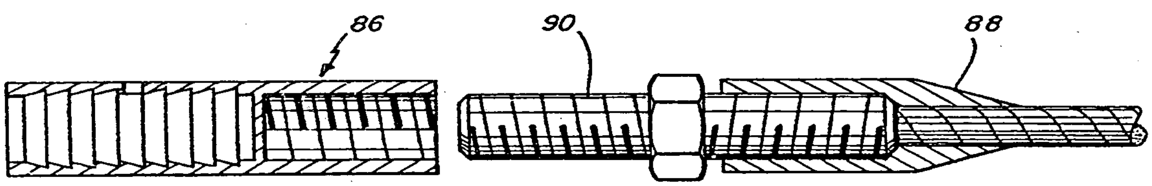


Fig. 15

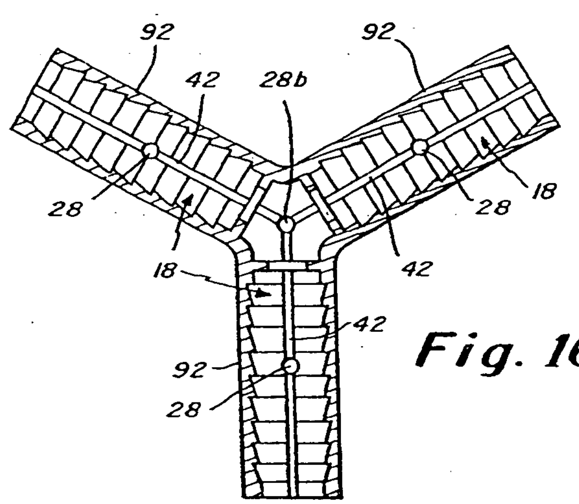


Fig. 16

SPECIFICATION

Joining rod shaped members

This application is a continuation-in-part of my prior U.S. Patent Application Serial No. 764,293 filed January 31, 1977. This invention concerns methods and apparatus for joining or splicing of bars, rods, and the like, such as concrete reinforcing bars. More particularly, the present invention is concerned with improved techniques for joining the ends of rebars in high load installations where the strength of the splice or joint may be of critical importance and where the joint must be capable of withstanding significant tensile loads. By way of example only, a joint having such characteristics is required in construction of nuclear reactors, tall buildings, other buildings which must be built to withstand seismic shock and the like. Such rebars typically are on the order of 1-1/4 inches minimum diameter and in some instances may be as large as three inches diameter, depending on the particular application. It is not uncommon in such high load applications for the bars to be expected to withstand stresses up to 100,000 psi and, of course, the joint or splice which connects the bars must be sufficiently strong to withstand such stresses.

A variety of techniques have been employed or suggested in the prior art to connect rebars to each other end-to-end. Perhaps among the most common techniques is to overlap the adjacent ends of a pair of rebars (for example, by an amount equal to twenty diameters of the bars) and to simply tie the bars together with wire, after which the concrete is poured over the bars and the overlapped joint. While this technique may be acceptable in structures which impose relatively little tensile load along the connected rebars, it is wholly unsuitable for installations of the type toward which the present invention is directed, where very substantial tensile loads must be resisted by the series of connected rebars. In this regard, it should be noted that the overlapped type of splice is used almost entirely with reinforcing bars of the order of one inch diameter and less, whereas the present invention is intended to be used primarily with substantially heavier rebars, having diameters of 1-1/4 inches and more.

Among the prior art techniques which have been suggested for joining heavy steel reinforcing bars of the type with which the present invention is concerned have been those which use molten metal to fuse or weld the ends of the bars together. For example, techniques have been proposed in which the adjacent ends of the bars are inserted into a metal sleeve which is then welded to the bars. Another technique which is in use at the present time is that of inserting the ends of the bars into the opposite ends of a sleeve and then filling the interior of the sleeve with molten metal which, upon solidifying, forms a primarily mechanical interlock between the encapsulated outer surface of the rebars and the internal surface of the sleeve. While this appears to provide a very strong joint when ,properly installed, it nevertheless presents numerous difficulties and leaves much to be desired.

For example, special crucibles, pouring basins, fittings and ceramic seals must be associated with and attached to the sleeve in precise relationship with each other and to the bars to be joined. The metal must be melted directly at the site which requires a considerable amount of supplementary equipment. The molten metal must be handled with care and precision, requiring a significant degree of skill. In addition, because of the complexity and delicacy associated with the operation, it may be very difficult to utilize this technique when it is necessary to work in confined spaces as, for example, when the bars to be joined are arranged in rows and layers. This technique may easily require two man-hours of labor for a single joint.

These difficulties are complicated further by the fact that the inventory of apparatus and fittings needed must be multiplied manifold for use with different size reinforcing bars and sleeves. It also is necessary to use differently shaped pouring basin assemblies and attachment fittings depending on the angle of the bars to the vertical, thus requiring more equipment. Typically, a different pouring basin assembly and attachment fittings are required for each 15° variation of the diagonal slope of the bars.

A further disadvantage of the molten metal type of joint is that it typically requires that both bars and the sleeve be joined simultaneously directly at the construction site. This is a distinct limitation in field use, especially in installations where the bars are not installed horizontally because of the necessity of holding multiple elements in vertical or diagonal alignment while the joint is made. Since the upper bar usually must be suspended by a crane (which is extremely costly), and the sleeve cannot easily be held in a precisely aligned position against the swinging weight of the upper bar, considerable time and effort is required to achieve proper alignment and casting of the joint.

Still other difficulties result from the configuration of the splicing sleeves used in the molten metal joint. Typically, such sleeves are provided with a single, small tap hole through which the molten metal is poured. It is extremely difficult, and in some circumstances impossible, to confirm visually through this tap hole whether or not the ends of the bars are located properly within the sleeve. Further difficulties result from the high temperatures of the molten metal. For example, the molten metal may tend to melt away parts of the inside of the sleeve, thereby reducing its tensile strength. The region of the sleeve about the tap hold is particularly susceptible. In the event that parts of the interior of the sleeve melt, there is no way to visually detect or simply determin whether this has occurred. Also, the high temperatures require the use of special seals and packing elements to seal the openings

at the ends of the sleeve between the sleeve and the bar to prevent leakage of molten metal.

Finally, in the event that a metal-filled joint fails, the failure tends to be instantaneous with little preliminary creep. Such failure can be catastrophic because as each joint fails, it throws the full load instantaneously onto the next joint in sequence which can tend to overload that joint and cause its failure.

The foregoing and other difficulties inherent with the technique of filling the interior of a splicing sleeve with molten metal have not gone unrecognized. Various proposals and suggestions have been made to provide other sleeve configurations and to use other filler materials and assembly techniques in an effort to avoid those difficulties. However, it does not appear that any reliable, commercially useable system has been developed, as evidenced by the fact that the molten metal technique continues to be used, notwithstanding its high cost and other disadvantages.

In general, such alternative proposals to the molten metal techniques fall into two categories. One relates to the use of a metal sleeve which receives the ends of the bars to be joined and which is then mechanically crimped, either by a cold forging or hot forging procedure, in an effort to effect a secure mechanical interlock between the sleeve and the deformities on the exterior of the rebars. The other category of proposals relates to the use of curable resinous or cementatious materials which can be poured into the sleeve and which are cured, hopefully, to effect a strong joint. None of these appears to have resulted in a reliable, commercially acceptable system. While these alternative techniques may be effective in providing a joint of sufficient strength to resist compressive loads on the rebars, they have not been capable of withstanding tensile loads of the nature and magnitude with which the present invention is concerned. In addition, it may be noted that the former of these techniques, which requires either hot or cold forging of the sleeve about the bars also requires relatively heavy, substantial equipment in order to apply the crimping forces to the sleeve necessary to effect the forging. As a result of the deficiencies in these alternative systems, they are not believed to have been useable to effect splices for high tensile loads.

It is among the primary objects of the present invention to provide an improved sleeve configuration and assembly techniques which provide the advantages resulting from the use of non-molten, ambient temperature filler materials, thus overcoming the difficulties inherent in molten metal-filled joints and providing a joint which is of substantial strength capable of resisting tensile loads of the magnitude toward which the present invention is direct d.

In accordance with the present invention, the joint is eff cted by a sleeve which is formed from cast steel or the like. Th sleeve has a central portion and a pair of sleeve segments, the bars being received through the open ends of the sleeve segments. The central portion of the sleeve is provided with internally extending fingers to limit the extend to which the bars may be inserted into the sleeve and also to provide a definite indication that each of the bars is fully and properly inserted. Each of the fingers is frangible which facilitates installation of the sleeve in some installation techniques described in more detail herein.

The inner surface of each sleeve segment is formed to define a plurality of annular V-shaped grooves, each of which defines a generally conical surface, there being an array of such grooves in each segment of the sleeve, The grooves in each segment are arranged so that they taper in a direction which extends toward the outer end of the sleeve segment and the grooves in each segment are arranged in contiguous, end-to-end series thereby to define a plurality of wedging surfaces extending fully along the internal surface of the sleeve.

Each segment of the sleeve is provided with a pair of longitudinally spaced injection apertures through which resin may be injected, under pressure, to fill the region between the sleeve and the received rebar. The injection apertures preferably are disposed on the same side of the sleeve and are arranged in general longitudinal alignment. The interior of the sleeve may be provided with a longitudinally extending groove which intersects the V-shaped grooves, to provide a path for air to escape from the interior of the sleeve when the filler material is injected. Preferably, the interior longitudinal groove is in communication with the injection apertures.

The inside diameter of the sleeve is uniform throughout the length of the sleeve and is sel cted with respect to the maximum diameter of the rebar so that there is a relatively small diametral clearance between the two, for example, of the order of 1/4 inch.

The sleeve may be provided with three or more radially mounted set screws at the end of each sleeve segment. The set screws provide an additional means to facilitate proper registry and orientation of the ends of the bars with each other as well as assuring proper spacing between the bars and the inner surface of the sleeve segments. The exterior surface of the sleeve may be tapered as it approaches the ends of its segments and the exterior surface also may be provided with a number of projections to enhance inter-locking of the exterior of the sleeve with the cement or concrete which will ultimately surround the sleeve in the completed installation.

When the sleeve is in place with respect to the bars to be joined, a resin, highly loaded with a filler material, is injected through one or more selected of the injection apertures to fill the remaining internal void with the r sinous material. Plugs may be provided for selected of apertures to enable the device to be used in a wide variety of configurations and in a complete range of installation situations. The sleeve assures that

there will be no internal voids and that the filler material will completely fill the region between the sleeve and the rebar. The resulting joint is one in which the tapered conical surfaces of the sleeve cooperate with the filler and external deformations of the rebar ends in a manner which significantly increases the tensile strength of the joint to a level corresponding to that achieved by the molten metal techniques, but without its attendant disadvantages.

It is among the objects of the invention to provide a new and improved method and apparatus for joining the ends of rebars.

Another object of the invention is to provide an improved rebar splicing system which enables a filled synthetic resin to be used as a filler material in a manner which results in a joint having high tensile strength.

A further object of the invention is to provide a rebar splicing system of the type described which is inexpensive and requires little supplementary equipment.

Another object of the invention is to provide a rebar splicing system which avoids complicated and hazardous apparatus using molten metal and which avoids the various difficulties and complications resulting from such molten metal techniques.

Another object of the invention is to provide a technique which avoids the need for large and complicated inventories of equipment, fittings, seals and the like to accommodate variations between horizontal, vertical and diagonal alignments of the bars to be joined.

A further object of the invention is to provide a rebar splicing technique which does not require assembly of the entire joint at one time but, rather, enables the sleeve to be attached to one of the rebars, the other bar being attached at some later time.

Still another object of the invention is to provide a rebar splicing technique which can be utilized in the formation of a multi-sided joint, as for example, when an engineer or architect would prefer to specify three separate tensile stresses converging at a single point, or when the desirable thickness of the concrete is thin enough to make it desirable that both vertical and horizontal reinforcing bars should lie in the same plane and pass through each other rather than in separate layers.

The foregoing and other objects and advantages of the invention will be appreciated more fully from the following further description thereof, with reference to the accompanying drawings wherein:

FIG. 1 is a somewhat diagrammatic sectional elevation of a joint formed in accordance with one embodiment of the invention with the sleeve and bars arranged vertically and with the air vent groove omitted for clarity of illustration;

FIG. 2 is an illustration similar to FIG. 1 showing the rebars and sleeve arranged in a horizontal installation;

FIG. 2A is an end view of a puttied sleeve as seen along the line 2A—2A of FIG. 2;

FIG. 3 is an illustration of the sleeve being installed to the end of one bar, for attachment to another at a later time, for example, at the construction site;

FIG. 4 is a somewhat diagrammatic illustration of a horizontal installation of the sleeve of FIG. 1 on a single bar end;

FIG. 5 illustrates an end view of the sleeve with the bar inserted, the internal stops, the air vent groove, the wedges, the sealing ring for one side horizontal mount and the annular grooves and injection holes, and showing the relative angular location of these elements about the longitudinal axis of the device;

FIG. 6 is an illustration of the central portion of the sleeve with the bar omitted and as seen along the line 6—6 of FIG. 5, to show the relationship of internal stops and the ring and also showing the air vent groove;

FIG. 7 is a side elevation of a modified form of the invention;

FIG. 8 is an end elevation of the embodiment shown in FIG. 7 with the reinforcing rod shown in phantom and with the sleeve being spaced by set screws;

FIG. 8A is an enlarged cross-sectional illustration of a portion of the sleeve showing the configuration of the grooves, as seen along the line 8A—8A of FIG. 8;

FIGS. 9—11 illustrate the manner in which the sleeve may be used to securely join the ends of reinforcing rods extending from the adjacent ends of concrete columns;

FIG. 12 illustrates a pair of half sleeves having joinable male and female threaded portions which may be separately mounted on bar ends and then screwed together;

FIG. 13 illustrates a pair of oppositely threaded female half sleeves with an oppositely threaded coupling stud with which the two half sleeves, mounted on bars ends, may be screwed together without rotating either rebar;

FIG. 14 illustrates a female threaded half sleeve onto which a bolt passing through structural steel may be directly bolted;

FIG. 15 illustrates a female threaded half sleeve, the female threaded wire rope terminal and a stud with which the bar end may be directly connected to a cable; and

FIG. 16 illustrates a joint having three single bar sleeves for joining three bar ends at a common point.

Figs. 1—6 illustrate, somewhat diagrammatically, an embodiment of the invention which is adapted for use in vertical, horizontal or diagonal installations. As shown, the arrangement includes a sleeve indicated generally by the reference character 10. The sleeve preferably is cast, as from steel. The sleeve includes an intermediate or middle region and may be considered as having a pair of open nded sleeve segments, indicated by the reference characters 10a and 10b. The sleeve 10 is hollow and defines a longitudinally extending bor . The sle ve

segments 10a, 10b are intended to receive the ends of the reinforcing bars 12, 14 respectively. In order to insure full and proper insertion of the rebars 12, 14 into their associated sleeve segments 10a, 10b, the sleeve is provided with one or more (preferably two) fingers 16 which are formed integrally with the sleeve at its intermediate region and which project radially inwardly. The fingers 16 are formed so that they will project inwardly to an extend sufficient to serve as a stop to engage the innermost ends of the inserted rebars 12, 14.

The internal surface of the bore in each of the sleeve segments is formed to include a plurality of annular grooves, indicated generally as 18, which are illustrated more clearly in FIG. 6. Each groove 18 is generally V-shaped and includes a sloping, generally conical wall 20. The conical walls 20 are oriented to taper in a direction extending toward the outer end of the sleeve segment 10a or 10b in which they are located. Each groove 18 also includes a transverse wall 22 which defines a generally ring-shaped surface, extending generally radially of the sleeve. Thus, as shown, the series of conical walls 20 and transverse walls 22 define somewhat of a sawtooth cross-sectional configuration. Preferably, the conical walls 22 lie at an angle (indicated by the angle A in FIGS. 6 and 8A) with respect to the longitudinal axis of the sleeve segment which is between 5° and 15°. I have found that satisfactory results are obtained when the width of the transverse wall 22 is approximately 1/4 that of the conical wall 20. By way of example, the width of the conical wall may lie between 1/4 and 3/4 of an inch and the width of the transverse wall 22 may lie between 1/16 and 3/16 of an inch, preferably in a 4:1 ratio. I have found that the best results are achieved with a conical wall 20 of the order of 1/2 of an inch long and transverse wall 22 of the order of 1/8 inch long, with the depth of the groove 18 being substantially 1/8 inch.

FIG. 8A illustrates the grooves 18 in an enlarged exaggerated detail. It may be noted that the transverse wall 22 in each groove 18 is disposed at a small angle B to a radially extending plane. The angle B is selected so that the transverse wall 22 lies very close to a radial plane, and therefore occupies a practically insignificant portion of the length of the sleeve 4. Thus, the internal surface of the sleeve 4 is defined almost substantially in its entirety by the wedging conical walls 20. The slight angle B of the transverse wall 22 also facilitates manufacture of the core to be used in casting the sleeves. By way of example, the angle B may be as small as 1° or 2°, but in no case should it xceed that of th angle A. Preferably, angl B should be between 2° and 8°. The slight angle B also is desirable in that it tends to assure that the resin will flow fully into all the grooves defining the interior of the sleeve segments.

The inner diameter of the sleeve is defined by the series of circular edges 24 defined by the juncture of each transverse wall 22 with the inner edge of its adjacent conical wall 20 of the adjacent groove 18. The grooves 18 are formed so that the inner diameters 24 which they define are uniform and substantially the same throughout the length of the sleeve. The inner diameter of the bore is selected with respect to the diameter of the rebar which is to be received so that the clearance between the rebar and the inner sleeve bore is relatively small, for example, of the order of 14" difference between the diameter of the bar and the diameter of the sleeve bore. In this regard, it may be noted that the reinforcing bars are formed so that their outer surfaces include deformations 26 which project radially from the surface of the bar to enhance the grip on the bar by the material in which it is to be embedded. The deformations 26 define a slightly larger diameter than that of the main portion of the bar. Thus, the rebars may be considered as having a primary diameter D_p measured across the main portions of the bar and a maximum diameter D_m measured across the deformations 26 (see FIG. 1). The diametral clearance between the bars and the bore (as defined by the edges 24) is measured with respect to the larger diameter D_m of the bars as measured across the deformations. The narrow clearance between the bar and the inner surface of the sleeve results in a comparatively thin layer of filler material between the bar and the sleeve which contributes to the significantly improved tensile strength of the joint. It is preferred to maintain the space between the bar and the inner diameter of the sleeve at a minimum so as to reduce the radial thickness of the resin filler and minimize the development of concentrated shear stresses in the filler. Satisfactory results may be achieved with diameter differences between 3/16" and 3/8", with 1/4" difference being preferred. Similarly, the depth of the grooves 18 preferably lies between approximately 1/8" and 3/16" depth. In general, the depth of the grooves 18 is substantially equal to the radial clearance between the sleeve and the bar.

From the foregoing, it will be appreciated that when the joint is formed and cured, the filler material will be mechanically interlocked with the deformations 26 on the bar and the material also will be interlocked with the series of wedging grooves 18. Upon the application with the series of wedging grooves 18. Upon the application of a tensile load to the joint, the cooperation between the filler material and the conical wedging surfaces 20 acts to compress the resin radially inwardly to an extend depending on the magnitude of the tensile load applied. Thus, as the tensile load increases, the radially inward compression on the resin also incr ases to effect a firmer grip between the resin and the deformation 26 on the bar.

Among th features of the present invention is that the compression effected by the conical surfaces 20 is substantailly uniform along the length of the joint. For example, the compressive force applied to the more inwardly disposed portions of the rebars is of the same order of

magnitude as that which is applied to those regions of the bar which are disposed at the more outward portions of the sleeve segments. Thus, the present invention provides an arrangement in which the compressive gripping force on the bar is transmitted substantially uniformly through the filler material which minimizes development of high stress concentrations within the cured filler material. It should be noted further that by forming grooves 19 so that they are arranged in contiguous, end-to-end series, substantially the entire inner surface of the sleeve provides the uniform wedging action so that substantially the entire inner surface of the sleeve may be considered as "working surface."

The gain in joint tensile strength with the foregoing configuration over the prior types of resin filled joints which have been proposed is very substantial. I have found that within the present invention, a joint having a tensile strength approximately equal to that of a metal filled joint may be achieved, and, in a significant number of instances, a joint formed in accordance with the present invention has displayed a tensile strength exceeding that of the reinforcing bar itself. As a result, the present invention enables a sleeve of shorter length to be used which facilitates handling of the sleeve as well as providing economies of manufacture. It should be noted that it is preferred to employ a sleeve which is as short as possible while still providing a joint of adequate tensile strength.

The resin filler may be selected from a variety of epoxy and polyester resin which are highly loaded or "filled" with particles of a hard filler material which is substantially incompressible within the range of stresses which are to be encountered. For example, satisfactory results have been achieved using an epoxy resin of a bisphenol-A/epichlorohydrin reaction, filled with aluminum particles between 1 to 35 microns in size. The aluminum particles constitute approximately 60% by weight of the mass of the filler material. By way of example, I have found a resin manufactured by Hapco Manufacturing Company, Inc., Hanover, Massachusetts, under formulation 1287, to be quite satisfactory. This resin formulation displays a compression strength on the order of 44000 psi. The resin will gell in approximately 28 minutes at approximately 25° Centigrade.

Other filler materials may be employed depending on the strength required, the cost involved, as well as considerations of electrical conductivity or coefficients of expansion should they become significant factors in the particular installation. In general, the compressive strength of the fully cured resin is preferably not less than 25000 psi. For example, particulate filler materials may be alumina (aluminum oxide, Al_2O_3), silica (silicon dioxide SiO_2), short glass fibers or metallic powders such as steel or aluminum. In general, the particle sized may li in the range of 1 to 35 microns. The factors to be considered in selecting a particulate filler material include the amount of particle surface which can be wetted by a given amount of resin and the extent to which the viscosity of the resin/filler mixture will increase as the filler is added. In general, as the particle sizes increase, less resin is required to wet a given weight of filler. By way of further example, a typical limit on the amount of filler which may be added to the resin is two to three parts of filler to one part of resin by weight. As these proportions, with uncatalyzed viscosities (which vary considerably with temperature) usually ranging from 20,000 to 200,000 centipoises (on a logarithmic scale in which water equals one centipose of viscosity), the wetting ability of the resin is largely utilized, and the viscosity of the mixture is approaching the point where it would not dependably penetrate the spaces between the bar and the sleeve, even under pressure.

Also among the desirable features of the resin is that it should cure fully under ambient working temperatures, preferably down to the lowest temperature at which it is feasible to pour concrete. Some resins which are now available will cure down to 35°F or even 0°F (with slower curing times). The resin also is preferred to be selected from those having a comparatively short pot life (the time between the beginning of mixing and the beginning of gelling). A comparatively short pot life, of the order of 5 to 15 minutes, is preferred for a number of reasons. First, short pot life helps to eliminate the slow leakage which can happen with such resins and helps to avoid the "topping off" of the resin and the sleeve which can sometimes become necessary with a resin having a comparatively long pot life. Secondly, because a short pot life usually is associated with a shorter curing time, the joint will be serviceable sooner. Short pot life is also important in generating the speed and confidence with which a worker can install a joint, confirm that it is sound, and move on to the next joint.

The filler material is injected into the sleeve through injection apertures formed through the sleeve and indicated at 28. The material is injected under pressure, for example by a simple pressure injection device 30 which may carry a cartridge 32 containing the filler material. The pressure injection device 30 preferably is fitted with a nozzle 34 of suitable shape and size to be inserted and sealed against the injection hole by hand pressure. Preferably the nozzle 34 is tapered, rounded and formed from slightly flexible plastic.

The sleeve may be used in any vertical, horizontal or diagonal attitude, without the need for special fittings and other supplementary devices as have been required in the prior art for high tensile strength joints. FIG. 1 illustrates a vertical installation of the invention. In assembling the joint, the lower segment 10a of the sleeve 10 is positioned on the upper end of the lower rebar 12 with the fingers 16 resting on the upper end of the lower rebar 12 to assure full and proper insertion of the bar into the sleeve segment. The upper rebar 14 is positioned within the upper sleeve segment 10b with its lower end also in engagement with the fingers 16. The annular

opening at the lower end of the sleeve segment 10a is sealed to the irregular outer surface of the rebar by a packing 36 of putty or an O-ring of soft material which may be pressed into the annular opening by hand. The packing 36 also may serve somewhat to maintain a generally even spacing between the bar and the sleeve to avoid direct contact between the bar and the sleeve which might adversely affect uniform flow of resin within the sleeve. Wedges 38 may be inserted into the annular opening at the upper end of the upper sleeve segment 10b, if desired, to maintain a desired even spacing between the upper bar 14 and its sleeve segment.

The assembled bars and sleeve then are ready to receive the filled resin material through one or more of the injection apertures 28. In the installation illustrated in FIG. 1, each sleeve segment 10a, 10b is provided with an injection aperture 28 which is located generally at the midportion of the sleeve segment. In this installation, a plastic plug 40 is inserted into the aperture 28 in the upper sleeve segment 10b and the nozzle 34 of the injection device 30 is urged into the injection aperture 28 in the lower sleeve segment 10a. The injection device then is operated to inject the resin through the lower injection hole 28 until the sleeve is filled and the resin is visible between the wedges 38 at the annular opening at the upper end of the upper sleeve segment 10b. The injection nozzle 38 is then withdrawn from the injection hole and another plastic plug 40 is inserted into the lower injection hole 28 to seal it and permit the resin filled joint to cure. The presence of resin at both ends of the sleeve provides visual confirmation of full penetration of the sleeve by the resin. In addition, the plugs 40 may be removed to further confirm full and proper filling of the sleeve.

FIG. 2 illustrates, diagramatically, a horizontal installation of a sleeve in accordance with the invention. As mentioned previously, the sleeve may be provided with a longitudinally extending vent groove which is indicated in FIG. 5 at reference character 42 but which is omitted from FIG. 2 for clarity of illustration (see also FIG. 6). Vent groove 42 extends longitudinally along and within each of the sleeve segments and intersects the grooves 18. The groove 42 preferably is in communication with the intersects the injection apertures 28. In the horizontal installation shown, the ends of the bars 12, 14 are inserted into the ends of the sleeve segments until they butt against the fingers 16. The sleeve is oriented so that its injection holes 28 and vent groove 42 are disposed on top. Wedges 38 are inserted into the annular opening at the ends of the sleeve segment to assure proper spacing between the bar ends and the inner surfaces of the sleeve segments. The ends of the sleeve segments are sealed by O-rings or putty 36 which may encompass the wedges 36 as shown. In the horizontal installation, the putty or ring 36 does not seal fully the annular opening between th sleeve segment and the bar. The putty is inserted so as to leave a space which does not block external communication of the outer ends of the vent groove 42 (see FIG. 2A). The nozzle 34 of the injection device 30 then is inserted into one of the injection apertures 28 to inject the resin. The vent groove 42 provides an escape for air to assure full and complete filling of the sleeve with resin, which may be confirmed by visual inspection through the other injection apertures 28.

FIG. 2 also incorporates an illustration of anohter arrangement of injection apertures, indicated at 28a, in which there are a plurality of such apertures 28a in each sleeve segment. In this arrangement, one of the apertures 28a is located adjacent the central region of the segment and the other aperture 28a is located near the outer end of the segment. The apertures 28a in each segment are aligned with each other, longitudinally of the sleeve, and as described above, also are in communication with the vent groove 42. In this arrangement, the sleeve would be oriented with the apertures 28a facing upwardly to receive the resin from the injection device 30, as described.

FIG. 3 illustrates the vertical installation of a sleeve 10 on the end of a single bar, with the other bar end to be installed at some later time. As mentioned, the present invention facilitates such one-bar installation and enables the joint to be partially formed at the steel fabricator before shipping. This results in significant saving of time, expense and effort in the field. In this installation technique, the sleeve 10 is positioned on the end of the single bar 12 with the fingers 16 resting on the upper end of the bar 12. The lower end of the sleeve is sealed to the bar with putty or an O-ring 36 and the pressure injection device 30 is then inserted into the lowermost injection aperture 28 to fill the lower sleeve segment. The lower sleeve segment is not filled fully but, rather, is filled with an amount of filler material less than half of the amount necessary to fill the sleeve in the two bar installation. Preferably about one-third of the amount required to completely fill the sleeve is used. After the desired amount of material has been injected into the lower segment of the sleeve, the injection device 30 is withdrawn and a plastic plug 40 is inserted into the aperture. It may be preferred in this type of installation to employ a sleeve having a pair of injection apertures in each segment. When that type of sleeve is employed, the lowermost aperture is employed as the injection aperture and the upper aperture may be permitted to remain open to provide a visual indication that the lower segment of the sleeve has been filled properly. The rebar, with the sleeve secured in place, then may be shipped to the construction site where it will be ready to receive the end of another rebar. When installing the other rebar, its end is inserted into the open end of the other sleeve segment until it rests against the internal fingers 16. Wedges or spacers are ins rted between the top end of the sleeve and the bar. The remaining amount of resin required (approximately two-thirds that required for a two-bar installation) then is injected into the sleeve

through the remaining injection holes until the resin appears at the upper end of the upper sleeve segment. The injection holes then are plugged by the plastic plugs 40.

FIG. 4 illustrates a horizontal installation of a sleeve on the end of a single bar so that the end of the other bar may be installed at a later time, after the first bar end is firmly attached. This may be desirable in some instances in the field where the first bar already has been partly secured in place in a horizontal or diagonally oriented attitude. In this installation technique, a thin metal disc 44 first is inserted into the sleeve segment and is urged toward the internal fingers 16 to seal the sleeve segments from each other. The disc 44 preferably is precoated with an adhesive or tacky film to facilitate secure seating. In order to provide an enhanced seating and sealing of the disc 44 within the sleeve, the middle region of the sleeve may be formed to include a ring-like shoulder 46 at the central portion of the sleeve (FIGS. 5 and 6). With the disc 44 securely in place to seal the sleeve segments the sleeve is passed over the end of the bar until the bar end rests against the metal disc 44. Wedges 38 and packing 36 may be inserted into the annular opening at the outer end of the sleeve segment between the sleeve and the bar as described in connection with the previous hoizontal installation technique. The resin then is injected through the injection aperture. When the second bar is subsequently installed, the same procedure is followed except that it is not necessary to insert a second metal disc 44.

FIGS. 7—11 illustrate some modifications of the invention in which the segments of the sleeve 10′ have generally tapering outer surfaces 50 so that the wall thickness near the outer ends of the sleeve segments is progressively less than the wall thickness near the midportion of the segments. This further serves to reduce the material necessary in casting the sleeve to reduce its weight which, in turn, reduces shipping costs as well as operator fatigue from handling the relatively heavy sleeves. In addition, the outer surface of the sleeve preferably is formed to include a plurality of projections, such as the ring-like ridges 52 which enhance the interlocking of the outer surface of the sleeve with the surrounding cement or concrete in which the sleeve is to be embedded.

In the embodiment shown in FIGS. 7—11, the outermost ends of each of the sleeve segments include an enlarged flange 56. The flange may be provided with a plurality of radially extending set screws 58 threaded into the flange. The set screws provide a convenient and simple way of properly orienting the sleeve on the rebars to assure proper spacing as well as to provide support for the sleeve on the rebars when the installation is horizontal or diagonal, thereby omitting the need to use wedges. In addition, the use of the set screws 58 also provides somewhat of a clamping force to secure the sleeve in place firmly.

The sleeve 10′ illustrated in FIGS. 7—11 includes a further modification to the invention in which the fingers 16′ extend substantially into the interior of the sleeve. The fingers 16′ which are cast integrally with the sleeve metal are relatively slender and can be broken upon a firm impact. The frangible nature of the fingers 16′ provides further advantages in some installation techniques. For example, FIGS. 9—11 illustrate the manner in which a reinforced concrete column 60 is applied on a reinforced concrete pad 62 in which each of the column and pad having a plurality of reinforcing bars 12, 14 extending from their adjacent ends. Typically, a number of the protruding ends of the bars (indicated at 14b) on the column will not align properly within the bars (indicated at 12b) extending upwardly from the pad 62. It usually is necessary for workmen to hammer or otherwise impact the various bars to align them properly. This is an extremely difficult procedure, particularly where there are many reinforcing bars and where a number of them are located interiorly of the cluster and are difficult to reach (only one interior set of bars 12, 14 are shown in FIG. 9 for simplicity). In such circumstances, it is practically impossible to join the ends of the bars by sleeves using many of the prior techniques.

In accordance with the present invention, and as illustrated in FIGS. 9—11, the sleeves 10′ may be utilized to facilitate the alignment of the reinforcing bars as well as to provide a secure joint. As shown in FIG. 9, the sleeves may initially be placed on the upstanding ends of the reinforcing rods 12 in the pad 62. The sleeves 10′ are placed over the ends of the rebars 12 and are urged downwardly under a force which is sufficient to fracture the fingers 16′ to enable the sleeves to slide fully downwardly so that the upper ends of the pad rebars 12 will be exposed upwardly through the top of the sleeves (FIG. 11). After all of the upwardly extending rebars have been so sleeved, the reinforced column 60 then is positioned over the pad 62 (FIG. 9) so that a few of the bars 12a are aligned with a few of the bars 12a. The sleeves associated with those aligned pairs of bars (indicated at 10′a) then are raised to overlap the adjacent ends of the aligned bars and the sleeves may be secured in place by the set screws 58. With the overlapped sleeves 10′a holding the column 60 from lateral movement, crowbars and/or hammers may then be inserted into the interior of the cluster of rebar ends to align the remaining bar ends 12b, 14b. When all the bars have been so aligned, their associated sleeves are raised into an overlapping configuration, the sleeves are secured in place and then are filled with the filler material in the manner previously described. In some installations, it may be desirable to fill the first few of the aligned sleeves with resin and permit curing before aligning the remaining bars. In other installations, few of the sleeves 10′ may be mounted on the upwardly extending ends of the corresponding numbered bar 12A and secured thereto as in a single bar installation. After the resin has cured, the upwardly extending, open ends of the sleeves

10' can provide a guide to receive the corresponding downwardly extending bar ends 14b to help guide the column into place.

FIGS. 12-16 illustrate a number of sleeve devices adapted to be secured to a single bar end and in which the sleeve devices include a fettered segment to facilitate fettered connection of a single bar to some other structural member. The sleeve-like members illustrate further the versatility which the present invention provides for an architect or construction engineer in designing a structure. FIG. 12 shows male and female threaded half-sleeves 70, 72 respectively, which may be separately mounted on bar ends and then screwed together. FIG. 13 shows two oppositely threaded female half sleeves 74, 76 respectively, with an oppositely threaded coupling stud 78 with which the two half sleeves 74, 76 mounted on the bar ends may be screwed together without rotating either bar. FIG. 14 shows a female threaded half sleeve 80 into which a bolt 82 passing through a structural steel beam 84 may be directly bolted. FIG. 15 shows a female threaded half sleeve 86, a female threaded wire rope terminal 88, and a stud 90 with which the bar end may be directly connected to the cable.

FIG. 16 shows a joint comprising three single bar sleeves 92 integrally connected at a common center for joining three bar ends at a point where three tensile stresses converge. This joint is useful in constructing a hexagonal bar structure for maximum reinforcement with a minimum of materials. The joint includes the V-shaped grooves 19 in each segment, as well as the air vent grooves 42, injection holes 28 in the segments and may include a central injection hole 28b in the central portion of the device. As with the previously described embodiments, the injection apertures all are in communication with the vent groove 42.

Thus, I have described the invention by which the ends of reinforcing bars may be joined securely in a very strong tensile joint and with uncomplicated, simple and comparatively inexpensive procedures. The difficulties encountered with the use of molten metal joints are avoided. It should be understood, however, that the foregoing description of the invention is intended merely to be illustrative thereof and that other embodiments and modifications may be apparent to those skilled in the art without departing from its spirit.

Having thus described the invention, what I desire to claim and secure by Letters Patent is:

CLAIMS

1. A structural joint securing the ends of a plurality of rods to each other in end-to-end relation comprising:

a sleeve-like member having a bore extending therethrough, the bore terminating in open ends;

the ends of the rods extending through the open ends of the member and into the bore, the inner ends of the rods being disposed in face-to-face relation within the bore whereby one segment of the member will surround an end of one of the bars and another segment of the sleeve will surround the end of another of the bars;

the internal surface of the bore in each segment being formed to define a plurality of annular grooves having a primary surface of generally conical configuration, there being an array of such grooves in each segment of the member;

the grooves in each segment being arranged so that their primary surfaces taper in a direction which extends toward the open end of the sleeve segment, the grooves in each segment being formed substantially along the full length of the sleeve segment and being arranged in contiguous end-to-end series thereby to define a plurality of continuous wedging surfaces along the interior of the segment;

each of the rods being smaller in cross section than the bore of its associated segment thereby defining a void between the outer surface of the rod and the inner surface of its associated bore;

the void being filled with a resin having a high compression strength, whereby upon a tensile load applied between the rod and the sleeve, said primary surfaces of said grooves will compress the resin to cause the resin to grip the rod under an increased force, said compression being applied to the bar substantially uniformly along the length of the sleeve segment.

2. A joint as defined in claim 1 further comprising:

at least one internal protrusion formed integrally with the interior of the sleeve-like member at a location between the sleeve segments, said internal protrusion being in engagement with the end of each of the rods disposed within the sleeve and being located between the segments of the sleeve thereby defining a predetermined separation between the inwardly facing ends of the bars.

3. A joint as defined in claim 1 further comprising:

the surface of the bars disposed within the sleeve having deformations projecting from the bar and defining a plurality of surfaces interlocking with the resin.

4. A joint as defined in claim 3 further comprising:

the depth of each of said grooves being approximately equal to one-fourth the width of the groove primary surfaces.

5. A joint as defined in claim 3 wherein the depth of each groove is substantially equal to the radial clearance between the rod and the bore.

6. A device for effecting a structural splice of a plurality of rods comprising:

an elongate sleeve-like member having a bore extending therethrough, the member having a plurality of segments, each terminating in an opening at its end and being receptive to an end of a rod;

the interior surface of the bore in at least one of the segments being formed to define a plurality of annular grooves, each having a primary surface of a generally conical configuration, each primary

surface of the grooves tapering in a direction extending toward the outer end of the segment, the grooves being formed substantially along the full length of the segment and being arranged contiguously in substantially end-to-end series; and

means enabling a fluent resinous material to be injected into the member.

7. A device as defined in claim 6 further comprising:

each of the annular grooves being of a depth which is substantially equal to one-fourth of the width of its associated primary groove surface.

8. A device as defined in claim 6 wherein each of said primary surfaces define a cone angle of between 10° and 30°.

9. A device as defined in claim 6 wherein said rods are of a predetermined external dimension, the bore extending through the sleeve member being of a diameter which is between 1/8" and 3/8" greater than the cross sectional diameter of the rods.

10. A device as defined in claim 6 further comprising:

at least one projection formed integrally with the sleeve and extending interiorly of the bore at a location intermediate the segments and forming an abutment stop for engagement with an end of an inserted rod.

11. A device as defined in claim 10 wherein said projection is frangible.

12. A sleeve as defined in claim 6 wherein the means enabling the resin to be injected into the sleeve comprises:

at least one injection aperture formed in each of the segments of the sleeve.

13. A sleeve as defined in claim 12 further comprising plug means insertable into each of said apertures for selectively closing said apertures.

14. A sleeve as defined in claim 12 wherein each of the segments has at least two apertures formed therein, said apertures being longitudinally spaced along the segment.

15. A device as defined in claim 14 further comprising:

the interior of the segment having a longitudinally extending vent groove formed therein, the vent groove intersecting the grooves and being in communication with each of the injection apertures.

16. A sleeve as defined in claim 6 further comprising the juncture of the sleeve segments including a circular ring formed integrally with and extending inwardly from the inner surface of the bore, said projection extending radially inwardly from the ring.

17. A sleeve as defined in claim 6 further comprising a disc insertable into the bore, the disc being of a diameter greater than that of the inner diameter defined by the ring whereby the disc may be supported by the ring and substantially block communication between the interior of the sleeve segments.

18. A sleeve as defined in claim 6 further comprising:

a plurality of set screws threaded into radially extending, circumferentially spaced holes at the outer end of at least one of the segments, the set screws being adapted to project into the bore to be engageable with the outer surface of a rod received in the bore.

19. A device for attachment to the end of a structural rod comprising:

an elongate sleeve-like member having a bore extending therethrough, the bore terminating in an opening at the end of the member to receive an end of a rod;

the interior surface of the bore being formed to define a plurality of annular grooves, each having a primary surface of generally conical configuration, each of the primary surfaces of the grooves tapering in a direction extending toward the open end of the member, the grooves being arranged contiguously in substantially end-to-end series and extending substantially along the full length of the bore;

means enabling a fluent resinous material to be injected into the member; and

means at the other end of the sleeve-like member for enabling the other end of the m mber to be secured to another structural element.

20. A device as defined in claim 19 wherein the means at the other end of the member comprises a sleeve-like segment substantially identical to the rod-receptive portion of the member, and having a bore in communication with the first mentioned bore.

21. A device as defined in claim 19 further comprising:

said sleeve-like member being formed from cast steel and having a wall thickness which is at a maximum at its mid-portion, the wall thickness diminishing in a direction extending toward the outer end of each sleeve segment; and

the external surface of the segment being formed with a plurality of projections to facilitate interlocking of the exterior surface of the sleeve with concrete in which the sleeve may be embedded.

22. A method of joining the ends of reinforcing bars comprising:

providing a sleeve having a plurality of segments, each segment terminating in an open rod-receiving end;

the bore within each of the sleeve segments being formed to define a plurality of annular grooves each having a primary surface of generally conical configuration, there being an array of such grooves in each segment of the member, the grooves in each segment being arranged so that their primary surfaces taper in a direction which extends toward the open end of the sleeve segment, the grooves in each segment being formed substantially along the full length of the sleeve segment and being arranged in continuous end-to-end series thereby to define a plurality of substantially continuous wedging surfaces along the interior of the segment;

inserting the ends of the bars into the sleeve segments;

then injecting a curable resinous material into the remaining void in the interior of the sleeve segments while substantially continuously venting the interior of the sleeve to the atmosphere.

23. A method as defined in claim 22 further comprising:

providing said sleeve with internal stops and inserting the ends of the bars until they butt said internal stops.

24. A method as defined in claim 22 further comprising:

providing the interior of the sleeve with a frangible stop;

initially inserting the end of one of the bars into one of the sleeve segments under a force sufficient to break the stop, and thereafter sliding the sleeve fully down said bar until the end of the bar projects through the other end of the other segment;

thereafter aligning a second bar with the projecting end of the first mentioned bar; and

thereafter moving the sleeve so that it overlaps the adjacent ends of the aligned bars.

25. A method as defined in claim 22 wherein the step of injecting the resin comprises:

providing a pair of apertures at each end of each segment and injecting the resin through one of the apertures.

26. A method as defined in claim 22 further comprising:

preliminarily inserting a disc into the interior of the sleeve between the inner ends of adjacent sleeve segments to seal one of the segments from the other; inserting the end of one bar into the sealed segment and injecting resin through an aperture in the side of the sleeve into the sleeve segment thereby securing the sleeve to a single bar and leaving the other sleeve segment open to receive a bar end at a later time.

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